Scheduling for Internet of Things Applications on Cloud: A Review

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Abstract: Internet is nothing but, interconnection of networks and it is evolved long ago in this world. Internet and things are two separate pillars in our world. So there is an integration of these two pillars to form a new terminology called Internet of Things. Cloud computing and Internet of Things are two important technologies evolved in the field of ubiquitous computing. Since Cloud computing is a pay as you go model, so it also provides services to its consumers on demand. So it is need to deploy cloud services in an IoT Environment. In this paper, we have proposed several existing scheduling algorithms used in a cloud and it is also related to IoT. This paper would benefit researchers to solve resource management problem in Cloud based IoT Environment.

Key Terms: Scheduling, cloud computing, Internet of Things cloud, DSS, DDSS.

1. Introduction

Internet of Things (IoT) is a novel paradigm which contains both dynamic and global networked Infrastructure. It also manages self configuring nodes (things) with high Intelligence. It consists of small objects (things) with limited memory storage and computing capacity in real world things, the architecture of IoT is given in figure 1.1. Cloud computing has virtually unlimited capabilities in terms of storage and processing power and it does not constitute real world entities. So there is a need for combination of these two technologies i.e. IoT and Cloud and it is called IoT Cloud or Cloud of things is a novel paradigm used to solve many research issues in future Internet[1].

Cloud can provide the intermediate layer between the things and the applications, for hiding the complexities in IoT. Heterogeneity is one of important characteristics of IoT [2], so there is a lack of certain important properties such as scalability, interoperability, flexibility, reliability, efficiency, availability, and security, these properties can be achieved by integration of Cloud with IoT environment.

Cloud computing reduces the capital Infrastructure expenses to its owner by providing resources rental only pay for usage model. Cloud computing is a best suitable solution for IoT problems such as energy efficiency, optimization of hardware and software resource utilization and flexibility [3]. IoT Cloud is more scalable in its computation and storage by handling large number of requests from the user. The remaining of this paper organizes as follows. Section 2 discusses some of the cloud computing related works and techniques are tabulated. Section 3 gives brief explanation of Non-preemptive scheduling techniques. Finally, section 4 concludes the paper.

2. Review of Literature

Lakra et al., [4] had proposed Multi objective based task scheduling in cloud computing scenario using heterogeneous system. In this algorithm helps to enhance Quality of service parameters such as execution time, bandwidth whereas only execution time is considered in other task scheduling algorithms. Virtual Machines is utilized as a cloud data centers for completion of task in an effective
way. Throughput time is increased by using different virtual machines in the different cloud data centers. The results are tested by using Cloud Sim simulator.

Haito et al., [5] proposed an effective scheduling approach for delay bounded tasks in hybrid clouds. This algorithm helps to schedule uncertainty tasks from private cloud data center and it also minimizes costs and improves Quality of Service parameter. Particle Swarm optimization technique is used to increase throughput and it also reduce the cost of private cloud data center whereas delay is increased in this mechanism.

HE Hua et al., [6] proposed a mechanism using PSO (Particle Swarm optimization) technique for adaptive multi objective task scheduling in cloud. So it enables the systems to maximize resource utilization and minimize task completion time for the cloud systems. Simulation results show that the improved PSO algorithm can obtain quasi-optimal solutions for the task scheduling problem for the cloud based systems. In future it must be handle dynamic deployment of service availability in a heterogeneous system. Some of the programming techniques and limitations are listed in table 1 [7].

Hui Jiang et al., [8] proposed a mechanism for task scheduling for cloud based disassembly systems. This algorithm contains two objectives namely minimizing makespan cost of the disassembly service. Each algorithm uses different programming technique shown in table 2. Using NP Complete and Multi objective Genetic algorithm is used to solve cloud based disassembly service. Simulation result proves that algorithm generates a set of Pareto optimal solutions. The user can choose a preferred disassembly service among Pareto optimal solutions.

Table 1. Programming Technique

<table>
<thead>
<tr>
<th>Programming Technique</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node Centric Program</td>
<td>Does not promote portability</td>
</tr>
<tr>
<td>Data base approach</td>
<td>Does not support Application Logic</td>
</tr>
<tr>
<td>Macro programming</td>
<td>Hiding high level details from developers</td>
</tr>
<tr>
<td>Model driven Developement</td>
<td>Increases level of data abstraction</td>
</tr>
</tbody>
</table>

Guan Wang et al., [9] suggested a modern task scheduling algorithm for heterogeneous computing systems. This algorithm is evaluated using DAG (Direct acyclic graph) using some real application DAGs by comparison with some classical scheduling algorithms. Simulated results prove it better in terms of schedule length ratio, efficiency, and frequency. Table 2 summarizes various Scheduling mechanism related cloud based IoT Environment. It also gives clear description about tools and algorithms used in IoT Cloud.

Table 2. Programming framework

<table>
<thead>
<tr>
<th>Authors Name</th>
<th>Technique</th>
<th>Macro Programming</th>
<th>Model Driven Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong K et al., [10]</td>
<td>Suitable for PaaS(Platform as a Service)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Sivieri A et al., [11]</td>
<td>Designed for embedded platform</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Pérez JL et al., [12]</td>
<td>Service Provider Platform for RESTFUL API</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Blackstock M et al., [13]</td>
<td>WOT KIT processor, Node Red</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Azzara A et al., [14]</td>
<td>Communication through WSN (Wireless Sensor Network)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Nakagawa et al., [15]</td>
<td>Java Application for integration of smart device with cloud infrastructure</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Persson P et al., [16]</td>
<td>Unified Programming Model</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Khodadadi F et al., [17]</td>
<td>Exposing IoT services as RESTful APIs</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Patel P et al., [18]</td>
<td>Framework for development IoT Applications</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Nastic et al., [19]</td>
<td>Intent based Programming Model</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Ioannis A. Moschakis et al., [20] had proposed a mechanism for scheduling IoT applications using simulated annealing approach in cloud. In this work, they have evaluated the application of simulated annealing in a multi-cloud system serving a workload of processes with low parallelism but with high arrival rates and highly variant run-times. However a discrete event simulator is used to assess the performance and cost of the IoT based cloud systems. In this process they have compared SQA (Greedy Method) with SA
(Simulated Annealing) approach for scheduling the Jobs of IoT in the cloud environments. Therefore, the experiments results prove that SA (Simulated approach) is more suitable for cost and job optimization for IoT tasks in cloud. IoT paradigms and the simulations tools are tabulated in table 3.

### Table 3. IoT paradigm and simulations Tools

<table>
<thead>
<tr>
<th>Title</th>
<th>Tool</th>
<th>Algorithm</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Data-Centric Framework for Development and Deployment of Internet of Things Applications In Clouds [21]</td>
<td>Aneka Cloud</td>
<td>No</td>
<td>It is just a framework model to schedule IoT application in a cloud environment using Aneka Cloud architecture model</td>
</tr>
<tr>
<td>Scheduling internet of things applications in cloud computing [22]</td>
<td>-</td>
<td>DSSs, DDSS, DDSS-h</td>
<td>These three algorithms are compared using mathematical model based on queuing theory is proposed based on criteria such as service arrival rate and processing requests rate. Its throughput is 50% and latency time is reduced</td>
</tr>
<tr>
<td>Solving complex task scheduling by a hybrid genetic algorithm [23]</td>
<td>C++, Gantt Chart</td>
<td>Teaching Learning Based Optimization Algorithm</td>
<td>It is implemented in IoT</td>
</tr>
<tr>
<td>QoS-alert Markov Chain based Scheduling Scheme in Internet of Things [24]</td>
<td>MatLab</td>
<td>Markov Chain Model</td>
<td>It is a scheduling mechanism used for prioritizing traffic for IoT Data. It also increases throughput and optimizes the performances of real time data in IoT</td>
</tr>
<tr>
<td>IoT Solution for Scheduling in Transport Network [25]</td>
<td>MatLab</td>
<td>DANN Architecture, Artificial Neural Networks</td>
<td>It mainly rely on fleet services in the transport network. It also reduces traffic and costs in the fleet management.</td>
</tr>
<tr>
<td>TTSA: An Effective Scheduling Approach for Delay Bounded Tasks in Hybrid Clouds [5]</td>
<td>MatLab</td>
<td>Hybrid Heuristic Algorithm, Particle Swarm Optimization, TTSA</td>
<td>Cost effectiveness is the main objective in this approach. Hybrid clouds is used to reduce data transfer from Public cloud and Private Cloud data center (CDC)</td>
</tr>
<tr>
<td>TRS: Temporal Request Scheduling with bounded delay assurance in a green cloud data center [19]</td>
<td>MatLab</td>
<td>Hybrid annealing approach, Hybrid Heuristic Algorithm</td>
<td>It effectively schedule all user requests in green cloud data center with delay bound constraints</td>
</tr>
</tbody>
</table>

### 3. Scheduling

The scheduling algorithm can be classified into two types they are consideration of request class and non consideration of request class [26]. In non consideration of request class is grouped into static / dynamic centralized / distributed, batch / immediate and co-operative / non co-operative, whereas consideration of request class is grouped into preemptive and non preemptive. Pre-emptive type is widely used for task scheduling, so it is not suitable for IoT Cloud environment. The non preemptive model has low delay and it is more suitable for IoT cloud Figure 3.1.

#### 3.1 Dedicated Server Scheduling (DSS)

The Dedicated Server Scheduling is a non preemptive scheduling. In DSS, the servers are dedicated for dedicated jobs. The server S1 scheduled for Job J1 and server S2 scheduled for Job J2 in the dedicated server scheduling. In DSS, if the job arrival rate is higher than the job processing rate, then the job will be scheduled in the queue. The jobs to the server is queued as (q1, q2, ...., qn), when there is possibility of processing rate is lower than the job arrival rate then jobs such as J1 is scheduled to q1, J2 scheduled to q2 and Jn scheduled to qn. The Job is dropped when the queue is full. In DSS, dedicated servers are not shared in heavy traffic. The increase in arrival rate of single job J will decrease the throughput of system.

#### 3.2 Dynamic Dedicated Server Scheduling (DDSS)

The Dynamic Dedicated Server Scheduling is grouped into two types they are Homogenous DDSS and heterogeneous DDSS-h. In DDSS/Homogenous DDSS servers are updated dynamically using virtual machines. The jobs assigned to servers dynamically.

\[
\text{Arrival rate of jobs (k)}
\]
Priority levels ($\Psi$)  
Present capacity ($M_{total}$)  
Total capacity ($M_{cl1}$)

$$M_{nm} = \left[ M_{total} \times \frac{\Psi \lambda_{t}}{\Psi 1 \lambda_{t1} \times \Psi 2 \lambda_{t2}} \right]$$

Scheduling

Non-Consideration of request class
  - Centralized / Distributed
  - Batch / Immediate
  - Static / Dynamic
  - Cooperative / Non Cooperative

Consideration of request class
  - Preemptive Scheduling
  - Non Preemptive Scheduling

Figure 3.1 Scheduling Types

4. Conclusion

Internet of Things and Cloud computing are two evolving modern technologies used in ubiquitous computing. Therefore, integration of these two technologies to solve more problems in Computation technology. However, it also contains more issues related to it, this paper merely emphasizes on scheduling mechanism in Cloud based IoT environment. In cloud all resources are termed as virtual with unlimited capacities, whereas IoT deal with real world entities. So by integration of these two technologies, accompanies several advantages needed to this changing modern world. The ultimate goal of resource management in IoT cloud is to maximum utilization of resources with less energy consumption and also reduced cost estimation. It also emphasizes on processing service requests with maximization of Throughput and minimization of latency time.

5. References


